

ASF RADARSAT PROCESSOR SYSTEM PERFORMANCE SUMMARY

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ABSTRACT[†]

The Alaska SAR Facility (ASF) located at the University of Alaska Fairbanks (UAF) has been in operations since 1991 serving as a key data acquisition, processing, archive and distribution center for a number of polar orbiting SAR (synthetic aperture radar) satellites including ERS1/2 and JERS-1. A multi-year upgrade effort started in late 1994 has enabled ASF to handle RADARSAT data as well. In September 1996, the first of two phases of upgrade to the ASF Radar Processing System (RPS) was completed with the introduction of RADARSAT standard beam and Scan SAR mode data processing capabilities. The second phase of the upgrade was completed in September 1997 and added processing capabilities for the extended high beams as well as processing capabilities for left-looking beams taken for the RADARSAT Antarctic Mapping Project (RAMP). As these additional processing capabilities are added, the RPS SAR processors need to go through a series of validation/verification processes to ensure that the associated products meet performance specifications and therefore science needs. This paper describes the various processors involved with the RADARSAT upgrade, the verification process, and the measurement results to-date.

INTRODUCTION

The Alaska SAR Facility (ASF), situated at the University of Alaska at Fairbanks, has been acquiring, processing, and archiving synthetic aperture radar (SAR) data from a fleet of international polar orbiting satellites since 1991. It's support of the European ERS-1 satellite [1] gradually expanded to include the Japanese JERS-1 and the European ERS-2 as they came on-line [2]. Starting in late 1994, ASF embarked on a major upgrade effort [5, 16] to support the RADARSAT satellite which was launched in November 1995. RADARSAT [3] is a Canadian satellite that has onboard an advanced SAR sensor capable of collecting data using a number of Scan SAR modes in addition to a wide variety of conventional radar beams. Scan SAR modes are unique in their wide swath capability of up to 500 km versus the typical 100 km from the conventional beams. However, Scan SAR does pose a challenge in terms of maintaining acceptable radiometric fidelity in the image products.

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To accommodate RADARSAT, ASF has upgraded its custom hardware based Alaska SAR Processor (ASP) to handle the seven standard beams (S11 through S17), introduced a ScanSAR processor (SSP) [13] to process data collected with the four ScanSAR modes (SWA, SWB, SNA, SNB), and added a Precision Processor (PP) to handle all the non-ScanSAR mode data including the seven standard beams, seven extended incidence angle beams, three wide beamwidth beams, and five fine resolution beams. As of November 1997, image products of all seven standard beams produced on the ASP have completed validation and verification and all are determined to meet product specifications. The ScanSAR beam SWB product from the SSP has also completed verification, and so have the left- and right-looking standard S12 beams from the PP. The following sections provide a brief description of the SAR processing system at ASF, the processor/product verification process, measurement and performance results, and the plan for completing the verification of the remaining image beam/mode products.

ASF RADARSAT PROCESSOR SYSTEM OVERVIEW

A block diagram of the RADARSAT Processing System (RPS) [17] at ASF is depicted in Figure 1. It consists of three SAR data processors, a data conditioner, and a control processor. The control processor (CP) provides all processing job control functions and is responsible for directing and sequencing the appropriate processing jobs for the data conditioner and the SAR processors. It also hosts a graphical user interface (GUI) to enable operator input and intervention. The Raw Data Scanner (RDS) is the data conditioner responsible for ingesting downlink RADARSAT signal data recorded on either AMPLEX DCRS or SONY 11-i media, performing data decoding and conditioning functions, and staging the conditioned signal data on disks for subsequent ingestion by the SAR processors. The three RPSSAR processors are made up of the Alaska SAR Processor (ASP), the ScanSAR Processor (SSP) and the Precision Processor (PP). The ASP is a custom-built hardware processor that handles ERS-1/2 and JERS-1 before being updated to perform processing of RADARSAT standard beams as well. The SSP is a software based processor hosted on COTS (commercial off the shelf) hardware (specifically, the IBM SP2s) dedicated to processing data collected in the four RADARSAT ScanSAR modes [13]. The PP is also a software based processor which is co-hosted on the SSP platforms and is designed to handle the processing of the RADARSAT standard, extended, wide and fine beams.

RPS SAR PROCESSORS PERFORMANCE REQUIREMENTS

The RPS SAR processor/product performance are responsive to science requirements [4] and are categorized into three areas including, image performance, processing throughput, and image product format. The specific performance requirements for the RADARSAT standard beams are given in Table 1. They are applicable to both the ASP and the PP with exceptions as noted in the table. The ScanSAR modes requirements are given in Table II. These requirements are applicable to the SS1.

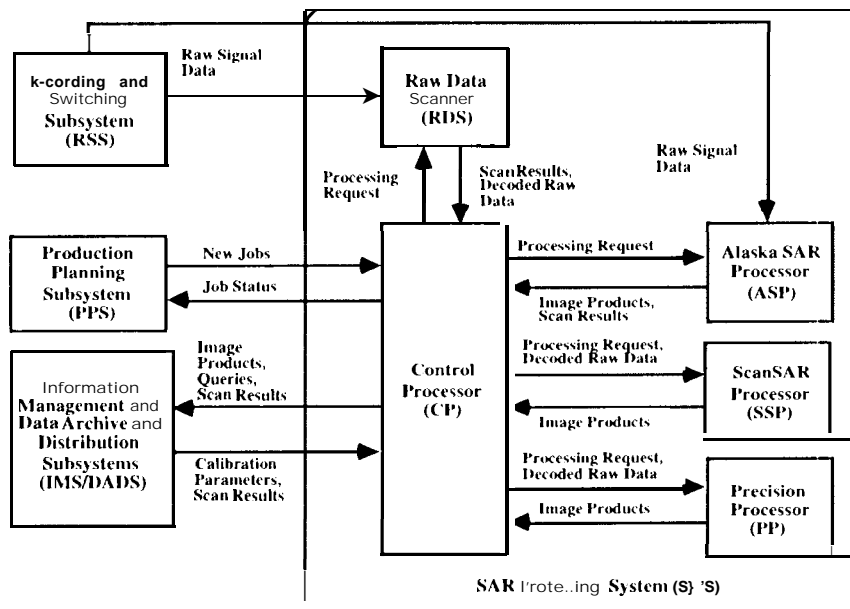


Figure 1. RPS Block Diagram

Table I. Standard Beam Processing Requirements.

MAGE SPECIFICATION

- Pixel Spacing
 - 12.5 m (full resolution), 100 m (low resolution)
- Impulse Response
 - 4 looks
 - 30 m nominal 3-dB resolution
 - 20 dB PSNR (goal, no specific requirement)
 - 13 dB 1-dimensional ISLR
- Geolocation
 - 500 m location accuracy, absolute
 - 0.2% scale error
 - 0.2% skew error
- Radiometric
 - +/- 2 dB radiometric error, absolute
 - +/- 1 dB radiometric error, relative
- Phase
 - +/- 3 degrees RMS for PP complex products

THROUGHPUT

- 60 minutes in a 16-hour day for ASP
- 7.5 minutes in a 5-hour day for PP

PRODUCT FORMAT

- CEOS compliant

Table 11. ScanSAR Mode Processing Requirements.

IMAGE SPECIFICATION
Pixel Spacing
50 / 100 / 400 m
Impulse Response
75 / 150 / 600 m nominal 3-dB range resolution
130 / 150 / 600 m nominal 3-dB azimuth resolution
-20 dB PSNR (goal, no specific requirement)
-13 dB 1-dimensional ISLR
-22 dB azimuth ambiguity ratio
Geolocation
500 m location accuracy, absolute
0.2% scale error
0.2 % skew error
Radiometric
+/- 2 dB radiometric error, absolute
+/- 0.5 dB radiometric error, relative
THROUGHPUT
51 minutes in a 11-hour day
PRODUCT FORMAT
CEOS compliant

VERIFICATION PROCESS

The verification process consists of establishing a number of calibration sites, acquiring RADARSAT data over the sites in the various beams and modes, processing the data using the respective processor(s), making performance measurements on the resulting output products, and applying adjustments to the processor(s) so that the appropriate performance specifications can be met.

Calibration Sites And Data Collection

Calibration sites are selected based on a number of criteria. Sites populated with suitable point targets such as corner reflectors and transponders of known locations and characteristics are well suited for impulse response and geolocation measurements whereas sites containing homogeneous scenes such as sea ice fields and tropical rain forests are excellent for supporting radiometric measurements. For convenience of data acquisition at ASF, calibration sites within the ASF reception antenna mask are deemed most desirable. For geolocation and impulse response verification, a calibration site maintained by ASF at Delta Junction, Alaska is used. This site is equipped with upwards of seventeen corner reflectors oriented to accommodate both ascending and descending satellite passes. In addition, the two ASF reception antenna themselves also prove to be valuable targets for geometric and impulse response evaluation purposes, especially for the relatively lower resolution ScanSAR mode images. For radiometric measurements, sea ice fields in the neighboring Beaufort Sea is used whenever possible. However, data collected over the

Amazon tropical rain forest is preferred due to its better known and stable characteristics. In most cases, required calibration data are collected at ASF via direct downlinks from the RADARSAT satellite. For data collected over the Amazon region, the data is first recorded on the on-board recorder for subsequent playback over ASF. In a few cases, data are collected at other ground stations around the world for shipment to ASF.

In support of the processor/product verification work, a set of data takes over each calibration site consisting of one ascending and one descending pass is required. In addition, a second set of data takes is also requested over point target sites such as Delta Junction for measurement confirmation purpose. Table III and IV show the verification data passes collected for the nominal right-looking standard beams and the ScanSAR modes respectively.

Measurement Tools

A suite of tools contained in the Product Verification System (PVS) [15, 18] is used to make measurements of the respective image products for comparison against the specifications given in Tables I and II above. This suite of tools is being refined as more experience is gained in the verification process. It also includes a CEOS (Committee on Earth Observing System) reader so that metadata contained in the image product can be decoded and checked as well.

Product Measurements And Processor Tuning

The verification data is first run through the respective processor. The resulting image product is then measured using tools contained in the PVS. Processing parameters in the processor are then tuned and any observed biases removed until the image performance meets specifications for both the ascending and descending pass(es). Some of the processor parameters adjusted to improve geolocation and impulse response performance include range pulse timing for cross-track location adjustment, state vector timing for along track location adjustment, and weighting functions for resolution and side-lobe control. For radiometric tuning, antenna beam patterns provided by the Canadian Space Agency (CSA) is used in conjunction with refined roll angle information to compensate for the range antenna pattern modulation. For ScanSAR data processing, a novel approach [6-12, 14] was devised to minimize the along track intensity scalloping as well as cross track beam-to-beam radiometric variation by refining the antenna pointing and tracking accuracy.

PROCESSOR PERFORMANCE

The processor/product verification of the RIS processors is still an ongoing process. While the ASP has completed verification of all seven standard RADARSAT beams, both the SSP and PP have just completed one beam/mode each. The following subsections pertain to the respective performance results obtained thus far.

AS1' Performance

The ASP has completed verification of all seven RADARSAT standard beams. With processor adjustments and tuning, all seven beams are shown to meet specification as illustrated in Table V. The only specification not listed at this time is absolute radiometric performance which will be calibrated using scenes with well known backscatter characteristic such as tropical rain forest and winter sea ice.

SS1' Performance

The SSP has completed verification of one of four RADARSAT ScanSAR modes. The SWB performance results for the 50 m and 100 m ground range products are shown in Table VI. The only specification not listed at this time is absolute radiometric performance which will be calibrated using scenes with well known backscatter characteristic such as tropical rain forest and winter sea ice. Figure 2 shows a representative ground range SWB ascending pass image over the Amazon region.

PP' Performance

The PP has completed verification of one of seven RADARSAT nominal right-looking standard beams. The ST2 beam performance results are illustrated in Table VII. The only specifications not listed at this time are (hc phase error for the complex products and the absolute radiometric performance which has yet been calibrated using scenes with well known backscatter characteristic such as tropical rain forest and winter sea ice.

SUMMARY AND STATUS

The processor/product verification work on the RPSSAR processors is ongoing. Calibration data in support of this work is still being collected. The most immediate emphasis is to initiate the verification of the left-looking standard (S1'2-7) and extended high (EH4) beams in support of RAMP (RADARSAT Antarctic Mapping Project). This phase of the work is expected to be completed by June of 1998. The nominal left-looking standard beams on the PP is expected to be completed by September of 1998, to be followed by the completion of all extended high beams in December of 1998. The remaining three ScanSAR modes are also expected to complete verification by December of 1998.

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